# Planning for a Sustainable Irrigation development: the Kosovo perspective

# *Planifier le développement durable de l'irrigation : quelle perspective pour le Kosovo ?*

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**Abstract.** Kosovo aims to revitalize its agricultural sector by modernizing and boosting irrigation development, which is vital for the economic growth and to overcome the ongoing rural desertification. The Kosovo Irrigation Master Plan (KIMP) establishes a national strategy for developing irrigation across the country. Following a systematic analysis of the land, water, agriculture, environment and economic sectors, the planning of the irrigation development has been done with the use of a GIS based analytical tool. The assessment of the water resources conducted both in the current and in the future climate change impacted situations have evidenced an exposed situation for the future foreseen development. Currently, the gross irrigation area is 20,000 Ha, but the plan has evidenced a potential of 280,000 Ha. With limited existing storage capacities and a predicted increased hydrologic variability, investing in irrigation infrastructures without a secured access to water resources appears to be hazardous and calls for the development of storage capacities. The economic and institutional sustainability of this development appears to be found only through a multipurpose management of the planned infrastructures. This article presents the studies conducted within the Kosovo national irrigation master plan.

**Résumé.** Afin d'enrayer l'exode rural et l'émigration, le gouvernement du Kosovo a initié une politique de relance de l'agriculture. L'accès à l'irrigation est un des leviers essentiels de cette politique. Le Kosovo Irrigation Master Plan-KIMP vise à établir une feuille de route pour investir dans le secteur de l'irrigation au niveau national, afin de doter le pays des infrastructures et du renforcement de capacités nécessaires. En se basant sur une analyse systémique des secteurs de l'eau, de l'agriculture, de l'environnement, du territoire et de l'économie, la planification du développement de l'irrigation s'est faite avec l'appui d'outils analytiques basés sur un SIG. L'analyse des ressources en eau développée dans la situation actuelle et dans une situation future tenant compte des prédictions du changement climatique a mis en évidence une situation critique pour le développement proposé. Actuellement, 20,000 Ha sont irrigués, mais le plan

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a déterminé un potentiel de 280,000 Ha irrigables. Avec des capacités de stockage limitées et des prédictions pour une grande variabilité hydrologique future, de gros investissements dans l'irrigation paraissent risqués et appellent au développement des capacités de stockage. La durabilité économique et institutionnelle d'un tel développement ne pourra être trouvée que par le biais d'une gestion multiusage de ces infrastructures. Cet article présente les études développées au cours du Kosovo Irrigation Master Plan.

## 1 Introduction

Kosovo aims to revitalize its agricultural sector by modernizing and boosting irrigation development, which is vital for the economic growth and to overcome the ongoing rural desertification. The Kosovo Irrigation Master Plan (KIMP) establishes a national strategy for developing irrigation across the country.

The approach adopted for the Kosovo Irrigation Master Plan sees irrigation as a sector at a crossroad of three major sectors: Land, Water and Agriculture happening into a global "environment". Following a systematic analysis of the land, water, agriculture, environment and economic sectors, the planning of the irrigation development has been done with the use of a GIS based analytical tool.

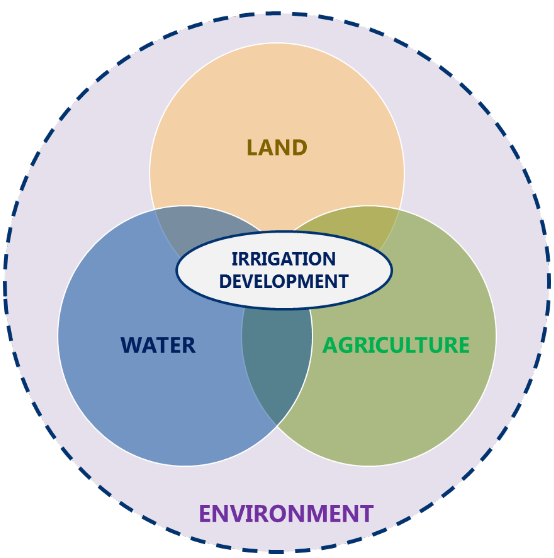


**Fig. 1.** Approach to the Irrigation sector.

## 2 Presentation of the planning process

The planning process aimed to identify the theoretical irrigation development potential by considering various criteria: technical, economic, environmental and social. The starting point was the creation of three major modules that were further combined into a spatial analysis tool.

1. The Land Module characterized the physical and natural characteristics of the Kosovo territory by analyzing the soil, topography and land use components, allowing to define the land suitable for irrigation development over the country.

2. The Agriculture module combined an Agro-climatic analysis together with an Agro-economic analysis. The first sub-module -Agro-climatic- calculates the Crop water requirements, allowing to estimate the irrigation water needs when joined with the land module. The second sub-module -Agro-economic- compiles for a crop dataset the production costs and the potential revenues, allowing to estimate the potential benefits of irrigation development when combined with the land module.

3. The Water module aims to characterize the water availability within the four major basins of Kosovo and their sub-basins. It is based on a rainfall-runoff (RR) model that has been calibrated with the available flow and rainfall data. The water demand has been calculated for each sub-basin detailing the demand for the a) Municipalities and Industries, b) Irrigated Agriculture, and c) the minimum environmental flow calculated from the results of the RR Model. The water module then allows to compute on a decade level a water balance analysis in conjunction with the results of the other modules.

The planning tool allowed to define, step by step the Kosovo Irrigation potential based on natural conditions, land use, water resources, and estimated the socio-economic impact its development could lead to.

## 3 Assessment of land resources

The modeling activities conducted for the assessment of the land potential led to estimate the erosion risk for the agricultural areas based on the LEAM Method [1] and to define the Land Suitability for Irrigation development following the Land Evaluation Methodology [2]. Around 630 000 Ha of land shows to be suitable for localized irrigation within the country. After analysis of the environmental aspects, only the agricultural lands were retained as a potential for being turned to irrigation. Thus, a total of 280,000 Ha was identified as potential area for irrigation development.

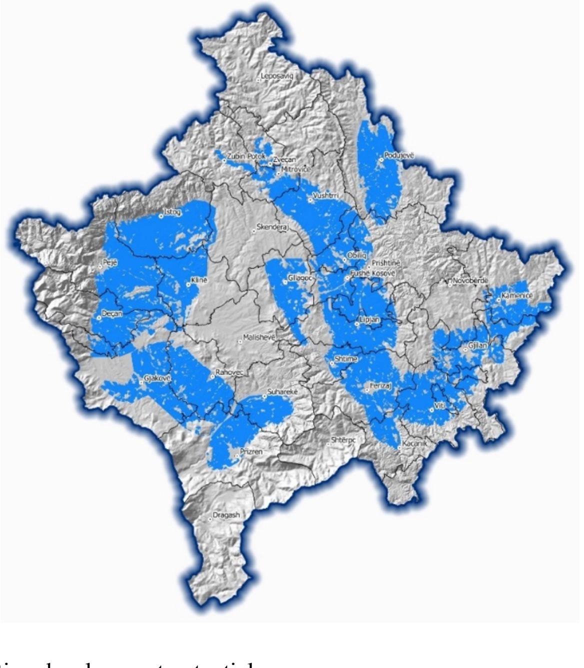


**Fig. 2.** Kosovo Irrigation development potential.

## 4 Assessment of water resources

The assessment of the existing water resources was conducted through the development of a rainfall run-off model [3]. While including results from models for regional climate projections [4], the team identified and assessed the future potential for the Kosovo water resources (rainfall, surface, ground water). The water resources assessment considered temporal and spatial distribution and, accessibility to the water resources. In an average year, the surface water productivity of Kosovo (i.e the volume of water flowing naturally in a year within the territory) has been estimated to 3.73 BCM out of which the Drini river accounts for 54.7%. Based on the model predictions, climate change will impact diversely the major water basins of Kosovo. With wetter winters the average annual value of available water per person might increase for the Drini and Iber rivers but decrease for the Morava. However, the major concerns are given by the predicted increase in temperature in summers (+2.5°c) and the decrease of precipitation in spring and summer (-10%). This will strongly impact agriculture and calls for a strategy to cope with the decrease in the available resources during the irrigation period and the predicted increased hydrologic variability.

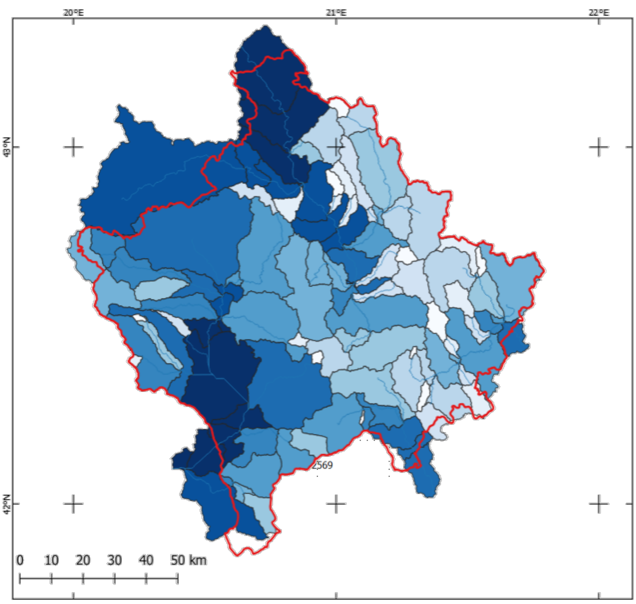


**Fig. 3.** Cumulative Annual Volume in MCM.

## 5 Analysis of the present and future agriculture systems

The Agricultural analysis started with the identification of six homogeneous agricultural areas across the country named Agro-Ecological Zones and to propose future cropping patterns for these zones. Further, Agriculture was assessed in a twofold analysis. First, an agro-climatic model based on the FAO I&D paper n°56 [5] led to the calculation of the irrigation water requirements. Gross irrigation requirements range from 3 500 to 5500 $m^3$/ha according to the agricultural zones and to the years (Average or Dry). Second, an agro-economic analysis allowed to estimate for a set of 26 crops the production costs and the potential benefits accrued from the irrigated agricultural production. A comparison of annual net benefits between the "without" and "with" project cases, shows that in the later case, they exceed the former between 4.3 and 11.2 times.

## 6 Water demand

The water demand has been computed on a decade basis both for the average and dry years and for the present and future situation considering the climate change. The water demand considers three sectors: Irrigated agriculture, Municipalities and Industry and Minimum environmental flow.

For the agricultural water demand, representative cropping patterns, considering access to water, were built for each of the six agro-ecological zones. A total gross area of nearly 280 000 Ha has been defined as a potential for irrigation development. Part of this area could be developed and irrigated for which the total annual water demand would range from 540 MCM in an average year to 675 MCM in a dry year.

The water demand for the municipalities was calculated based on the consumption data communicated by the Water Services Regulatory Authorities for 2018. As far as the future water demand, for the 2050 time horizon, the population forecast shows a small decrease of 8%. In order to stay conservative, current estimated consumption were kept as a reference also for 2050 time horizon.

The estimation of the Minimum Environmental Flow (MEF), relied on the results of the rainfall-runoff model. The MEF value considered was the maximum between Q95% (the flow that is on average exceeded 95% of the time) and 10% out of the mean discharge averaged on twenty years.

## 7 Water balance and analysis of the storage capacities

The water balance model allowed to compare for each basin and sub-basin, for each decade, the water demand (Irrigation, Environment, Municipal and Industry) and the water availability. Thus, the method calculated the deficit and the storage potential for each sub-basins, in particular where reservoirs are planned for construction. The list of reservoirs considered was given by the Ministry of Economic Development and Environment (MEE). These are multipurpose reservoirs existing or planned serving hydropower, flood control, irrigation and M&I demand. Considering the average water balance of the main basins, assuming that all the planned irrigation is implemented, the results of the water balance show that the shortages envisaged during the irrigation period calculated on a monthly basis, can be largely compensated with storage infrastructures exploiting the annual water yield.

**Table 1.** Summary of the results of the water balance model for the average year.

| Basin | Volume_MCM | MEF_m3/s | M&I_MCM | Irrigation_MCM | Deficit_MCM | Storage potential_MCM |
|---|---|---|---|---|---|---|
| Drini | 1,922 | 11.2 | 186 | 1 401 | 60.77 | 2 115 |
| Iber | 1,044 | 3.53 | 220 | 1 349 | 61.46 | 852 |
| Lepenc | 294 | 3.77 | 8 | 59 | 3.03 | 194 |
| Morava | 248 | 1.25 | 30 | 327 | 24.13 | 172 |
| Total | 3 508 | 20 | 444 | 3 136 | 149 | 3 333 |

The storage potential calculated with the water balance model is theoretical since most of the water storage infrastructure have not been physically considered in the model. The next step of the analysis was to compare the storage capacities of the existing and planned reservoirs in Kosovo with the storage potential in the 2050 situation. In absence of specific information on the planned reservoirs, the water volume potentially available for irrigation were considered as 80% of the usable volume. For the existing multipurpose reservoirs, the specific irrigation share was used. Based on these assumptions, the team identified out of the irrigation potential area defined which of these latter could be secured for irrigation development from the upstream multipurpose storages.

## 8 Present and planned storage capacities

The list of the existing and planned reservoirs for Kosovo with indication of their locations and physical characteristics was collected from the MEE. When developing the hydrologic models, these points were inserted to allow an extraction and a calculation of the storage potential at these points. The storage capacities were calculated for each reservoir.

Note that some water transfer may exist for some of these reservoirs but no data were made available. Kosovo has not yet developed a water Master plan that defines the water allocation for irrigation out of the existing resources and in particular for each reservoir. A value of 10% of dead storage was considered. For the live storage, a ratio of 80% of the calculated volume was considered to be available for irrigation development. The remaining 20% are used for other uses, in particular M&I. Environmental needs are considered to be satisfied as a priority and not accounted as storable volumes.

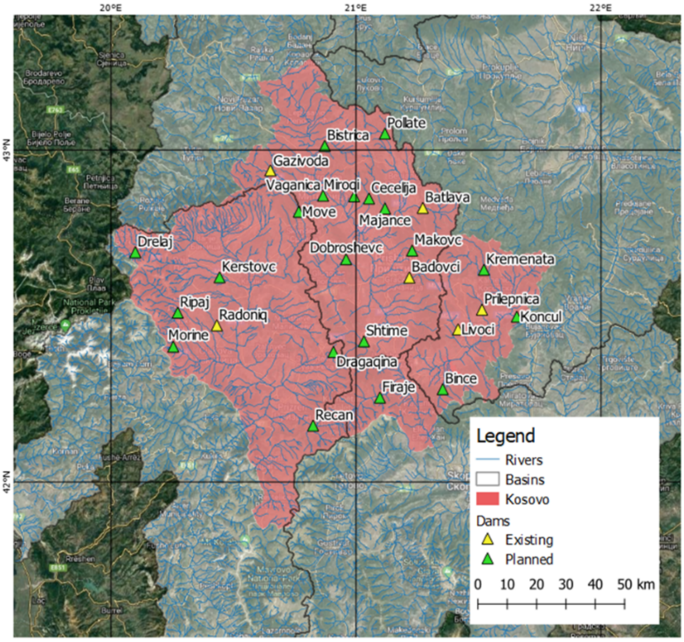


**Fig. 4.** Existing and planned reservoirs for Kosovo.

**Table 2.** Planned and calculated storage potential for the reservoirs.
*(in red are featured the reservoirs potentially impacted by the Lepenc diversion project)*

| Reservoir | Status | Planned Storage capacity (MCM) | Calculated Storage capacity (MCM) | Agriculture water resources (80%)(MCM) |
|---|---|---|---|---|
| Drelaj | Planned | 84,50 | 67,98 | 54,38 |
| Move | Planned | 34,00 | 13,82 | 11,06 |
| Morine | Planned | 38,00 | 6,11 | 4,89 |
| Ripaj | Planned | 36,00 | 3,70 | 2,96 |
| Recan | Planned | 68,00 | 37,57 | 30,06 |
| Dragaqina | Planned | 6,76 | 4,89 | 3,91 |
| Kremenata | Planned | 8,75 | 6,57 | 5,26 |
| Bince | Planned | 1,00 | 13,73 | 0,80 |
| Koncul | Planned | 120,00 | 170,00 | 96,00 |
| Firaje | Planned | 16,50 | 1,20 | 0,96 |
| Shtime | Planned | 113,00 | 30,61 | 24,49 |
| Cecelija | Planned | 21,00 | 5,29 | 4,23 |
| Makovc | Planned | 10,00 | 2,96 | 2,37 |
| Majance | Planned | 30,00 | 15,10 | 12,08 |
| Vaganica | Planned | 8,00 | 6,23 | 4,98 |
| Miroqi | Planned | 6,00 | 3,79 | 3,03 |
| Dobroshevc | Planned | 23,20 | 55,23 | 18,56 |
| Pollate | Planned | 37,50 | 18,32 | 14,66 |
| Bistrica | Planned | 25,00 | 26,67 | 20,00 |
| Kerstovc | Planned | 40,00 | 36,93 | 29,54 |
| Gazivoda | Existing | 370,00 | 370,00 | 185,00 |
| Radoniq | Existing | 130 | 130,00 | 80,00 |

Based on these assumptions and calculation results, the water resources stored in the planned reservoirs for irrigation could totalize 344 MCM. In addition to this, a consistent share of the water stored in the existing Radoniqi (80 MCMout of 130 MCM) and Gazivoda (50% of the stored 370 MCM) reservoirs can be added to secure irrigation development. Finally, a total storage of 620 MCM could theoretically be envisaged for irrigation development if all the planned multipurpose reservoirs were constructed.

# 9 Planned development

The identification of the irrigation areas that could be secured downstream the reservoirs has been realized with the support of the GIS tools. Based on the position of each reservoir, and after identification of the reservoir elevation, the planners have looked for the most suitable areas that could be served by gravity. The analysis is done based on an average year as it is done in the state of the art. The process of identification is illustrated in the schematic shown in Fig. below.

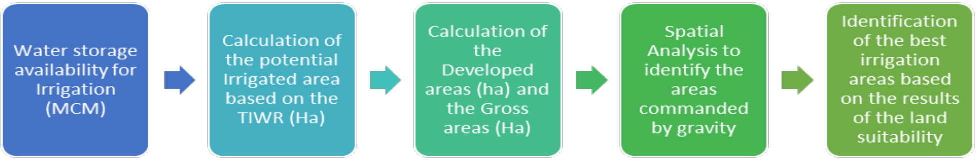


**Fig. 5.** Process for the identification of the irrigation areas secured downstream the dams.

With the existing storage capacities dedicated to irrigated agriculture, a total gross area of 38,700 Ha is secured while another 45,900 Ha can be irrigated by direct withdrawal from the rivers. The remaining 194,500 Ha of the Kosovo irrigation potential remains unsecured and shall look for individual or semi collective solutions*.

If Kosovo decides to develop its planned storage capacities, a total gross area of 176,800 Ha would be secured while 22,700 Ha could still be irrigated by direct withdrawal from the rivers. The remaining 79,600 Ha of the Kosovo irrigation potential remains unsecured. The graph on

Fig below shows the difference of the two situations with/without storage.

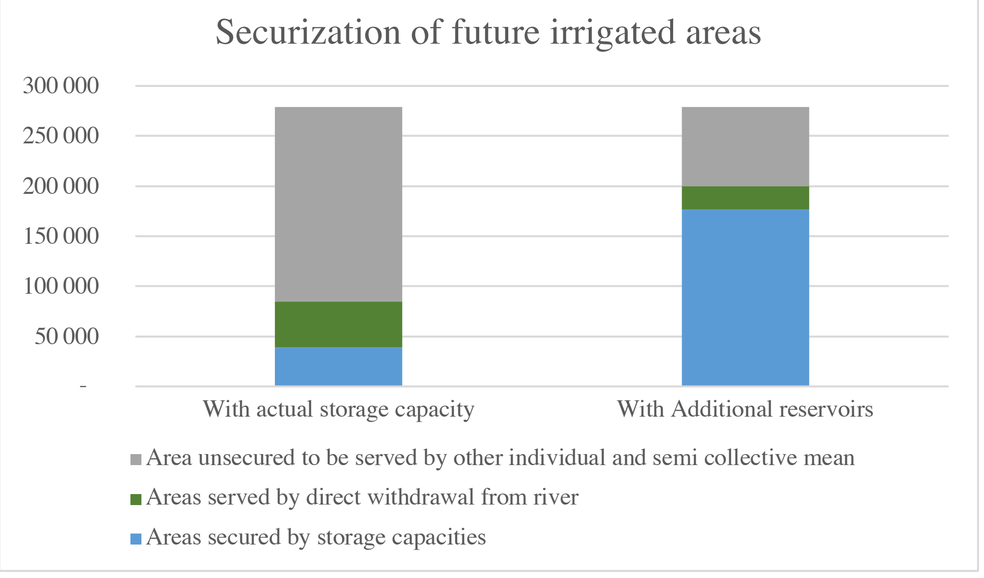


**Fig. 6.** Securization of future irrigated areas.

* Small dams, or direct pumping from groundwater

A multicriteria analysis (MCA) was further developed to identify among 24 irrigation project zones, which shall be prioritized according to short, medium and long term objectives of irrigation development. The MCA combined economic, technical, environmental and institutional factors. The Multipurpose use of the water infrastructure was addressed within the “institutional criteria” where projects situated downstream a multipurpose reservoir were granted with a higher institutional ranking, where multi users would consider a higher level of control. Finally, between the alternatives of a *with and without* additional storage scenario, the planners proposed a “balanced territorial solution with strategic dams” targeting the development of 136 000 Ha at a 25 years horizon with 107 000 Ha secured downstream storage reservoirs.

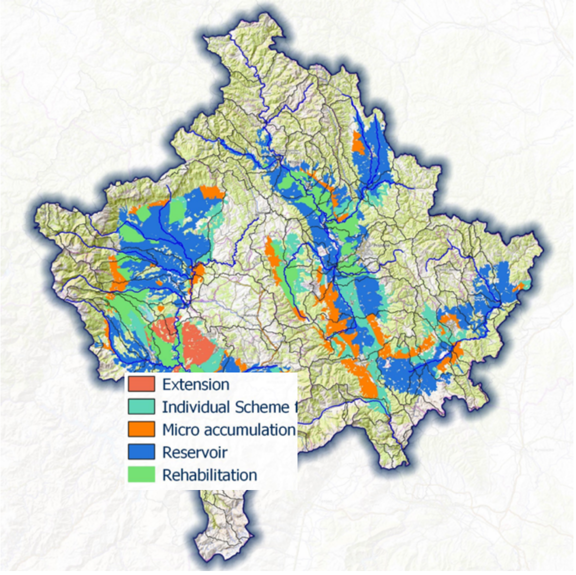


**Fig. 7.** Proposed development in the balanced territorial solution with storage reservoir.

## 10 The cost of providing a secured access to water

Based on the current Kosovo Institutional organization, responsibilities towards the investment of irrigation infrastructure pertains to the Ministry of Agriculture Forestry and Rural Development (MAFRD), whereas the investment in water related infrastructures, in particular storage, concerns MEE (See Fig). Thus, the Master plan only looked at the costs for the development of the conveyance and distribution networks from the source down to the farm plot, excluding the storage reservoirs.

The estimation of the required budget to build the irrigation infrastructure has been conducted during the Master Plan. Eight irrigation infrastructure types have been analyzed and affected to the different project zones following engineering considerations. The preliminary figures were refined after conducting 7 specific project studies at a pre-feasibility level. The Capex (capital expenditures) range from 5000 €/Ha for individual pumping solutions to 15000 €/Ha for small accumulation dams. The Opex (Annual Operation & Maintenance Expenditures) range from 90 €/Ha/Y for gravity scheme rehabilitation to 560 €/Ha/Y for individual schemes pumping from groundwater with diesel pumps. Globally, 1200 M€ of capital investment is necessary to cover the rehabilitation, extension and new scheme development works serving the selected 136 000 Ha.

Although very dependent to the local conditions, the investment costs for the realization of the multipurpose storage reservoirs can be estimated ranging from 0.5 to 1.0 €/m³ stored [6]. The water resources storage potential of the planned reservoirs could totalize 526 MCM out of which 344 MCM could be for irrigation purpose. The Capital investment for these storage capacities could range from 250 to 500 M€.

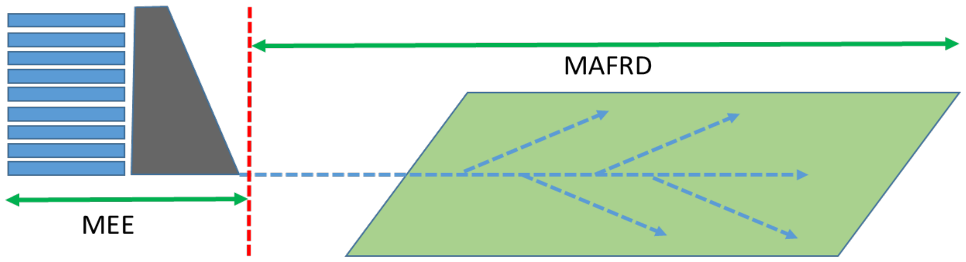


**Fig. 8.** Institutional responsibilities to cover the investments.

The cost of the multipurpose storage capacities was not considered within the financial analysis of the master plan. In the present situation, the income of other uses, in particular hydropower generation and the municipal and industrial uses are currently covering these reservoirs costs.

## 11 Viability of the proposed irrigation investments

The cost benefit analysis conducted both at the master plan level and at a prefeasibility level have suggested that the foreseen development projects are economically viable, and in part, also financially viable*: the additional benefits accrued from the increased irrigated agricultural production are bigger than the costs of irrigation development. In addition, the analysis of the [gross] profit gained at the farm level has shown that an irrigation fee of 250 €/Ha is viable for these future farm models that are assumed to evolve from self-sufficient to more commercial farming types. Under these conditions, the running costs of the water service (i.e. the costs of the annual operation, maintenance and energy expenditures) can be covered through irrigation tariffs. Although over the years such tariff may increase to cover other cost elements, it is unlikely that the full cost of the service, including the repayment of the capital investment, can be covered through irrigation fees.

An optimization can be found by assigning the management of these future irrigation infrastructures to the existing regional water companies and by reinforcing their role as multi-purpose operators. In fact, the water storage and conveyance infrastructures involved would also benefit to the following uses: municipal and industrial water supply, flood control, minimum environmental flow, hydropower, recreational, etc. Developing a multiple water tariff policy could help to share the cost recovery among users having different ability to pay. Hence, a cross subsidy mechanism towards the irrigation service price would be applied as it is done in France [7].

## 12 Financing of the investments

* As resulting from the economic and financial cost-benefit analyses.

The size of the proposed investments is considerable, and therefore it may not be realistic to expect that these will be fully funded through international aid institutions, also in light of the recent and more emergent needs generated by the recent pandemic. A possible way of funding these investments would be through a combination of public and private funds, through various blending finance schemes and options for PPPs (public private partnerships) especially as related with multipurpose reservoir development.

## 13 Conclusions

Kosovo looks to an ambitious program of irrigation development that would provide a necessary access to water to its rural areas. This is a prerequisite to engage in a transition to a more commercial agriculture and to provide an insurance in front of the climate change. The planning process developed under the Kosovo Irrigation Master Plan has evidenced that over a theoretical potential of 280,000 Ha, 136,000 Ha shall be retained for development, out of which 107,000 Ha shall be given a secured access to water downstream multipurpose reservoirs.

The sustainability of this ambitious irrigation program – from a technical, social, economic and environmental point of view – can only be met by addressing this improvement project through a global water investment program, supported by key institutional and regulatory reforms[*], indispensable as the enabling environment to foster the development objectives of the irrigation plan and the agriculture sector.

However, the water security of this irrigation program depends on the expansion of large storages capacities whom cost cannot be covered by the agriculture sector itself. Therefore, multipurpose uses of water storage and transportation infrastructures shall be inquired from the planning stage.

Multipurpose projects managed by the regional water companies with extended competences shall be able to generate the benefits from various water services to cover in the long term the project and systems' costs.

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[*] These have been detailed in the Action Plan. The most imminent is the land regulation and consolidation.